The Development of the Concept of Space

Katherine E. Simpkins

American Printing House for the Blind

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American Printing House for the Blind
Louisville, Kentucky

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Abstract

The blind child's concept of space and how this concept develops has been relatively little explored. Using the cognitive theory of Jean Piaget as a base, an overview of the conceptual development of space is presented as it occurs in sighted children. The outline is presented to provide a framework for studying notions of space in blind children.

The Development of the Concept of Space

Mobility has been called the "key to independence" (Koestler, 1976). For independent mobility, however, the individual must have an adequate knowledge of the surrounding environment. Koestler (1976) reports that as much as 80% of this knowledge is derived from vision. Knowledge of the environment involves an understanding of space to the extent that the blind individual feels secure in his/her movement through that space. Exploration of the blind child's development of spatial concepts has been minimal (Clarke, Pick, & Wilson, 1975; Foulke, 1971; Juurmaa, 1972; Schulz, 1972; Swallow, 1973; Swallow & Poulsen, 1972; Von Senden, 1960; Worchel, 1951), and much of this research has dealt primarily with the use of technical aids in assisting the blind individual to be mobile.

A series of studies has been undertaken at the American Printing House for the Blind to delineate elementary concepts of space as they develop in young blind children. To provide a framework for these studies, the author has utilized principally the works of Jean Piaget to suggest possible avenues of research. This paper presents an overview of various spatial concepts and their development based on Piaget's theory and studies of this theory with sighted children.

The earliest ideas of space may be seen in the infant's development of object permanence. About 4 to 5 months the infant begins to coordinate vision with prehension, but the objects grasped do not reflect permanency for when hidden the child frequently moves on to new interests. Yet this is the beginning of the differentiation between the object and the child's own actions on that object (Elkind, 1974; Piaget, 1954; Piaget & Inhelder, 1965). As the idea of object permanence progresses, the infant learns to search for hidden objects recognizing their existance though unseen or unperceived. This ability to search and find the hidden object culminates about 9 to 10 months of age (Beard, 1969; Elkind, 1974; Piaget, 1954; Piaget & Inhelder, 1965; Simpkins, 1977). Fraiberg (1977) found that this concept of object permanence developed much later in blind children (as late as 11 to 12 months) and was linked with attachment to mother.

The major study of space, however, has been set forth in two volumes: The Child's Conception of Space (Piaget & Inhelder, 1965) and The Child's Conception of Geometry (Piaget, Inhelder, & Szeminska, 1960). These two reports have been the impetus for many other studies indicating that the construction of the representation of space begins to emerge during the beginning of the concrete operational stage of reasoning development (ages 5 to 7 years). The construction of space is not perceptual, but rather conceptual. The child's conception of space develops in an invariant sequence of stages from topological relationships to projective and Euclidean relations (Larendeau & Pinard, 1970; Piaget & Inhelder, 1965; Siegel & Hooper, 1968; Smock, 1976, pp. 31-73).

Topological space deals with the internal relations of individual objects. The initial relation is proximity or "nearbyness."

The younger the child is the more important this relation becomes. But proximity also enables the child to begin to "separate" or distinguish one object or parts of an object from another. Building on the notions of proximity and separation, the child begins to understand the property of order or sequence. From these underlying concepts the child builds the idea of "betweenness" which is an instance of the idea that an element is enclosed or surrounded by other elements (Bass, 1975, pp. 45-70; Copeland, 1974; Flavell, 1963; Larendeau & Pinard, 1970; Piaget & Inhelder, 1965; Sauvy & Sauvy, 1974; Simpkins, 1978; Smock, 1976, pp. 31-73). The only shapes recognized and drawn at this level are closed, rounded shapes, and those based on simple topological relations such as openness or closure, proximity and separation (Smock, 1976, pp. 31-73). To assess these concepts several assessments were developed. Initially Piaget and Inhelder (1965) worked with children ages 2 to 7 years on the "haptic" perception of shapes. This study was replicated by Larendeau and Pinard (1970) with children ages 2 to 12 years. Results indicated that shapes, and in the latter study objects and shapes, when examined tactually were visually recognized on the basis of topological relations. When asked to draw some of the shapes, Piaget and Inhelder (1965) found that around 4 years of age Euclidean shapes were frequently lumped together. A square might be confused with a circle being drawn only as a closed figure. The relationship of enclosure or surrounding was explored through a study of knots and pseudo-knots. By visual inspection the child determined whether the knots or loops presented were true knots (See Figure 1). If there was not the necessary "surrounding" of the string, there would be no knot (Piaget & Inhelder, 1965; Smock, 1976, pp. 31-73).

Insert Figure 1 about here

Projective space begins developing at the point when objects are no longer viewed in isolation but in relation to the individual. The child begins to consider a "point of view" in relation to the object (perspective) and in relation to other objects (projective). The latter is built on the intercoordination of objects separated in space (Larendeau & Pinard, 1970; Piaget & Inhelder, 1965; Smock, 1976, pp. 31-73). One of the techniques used to assess the shift from topological representations to projective and Euclidean representations in the child's space is the construction of a straight line. In this task the child is asked to build a straight line of "telegraph poles" (Piaget & Inhelder, 1965), "lampposts" (Larendeau & Pinard, 1970), or "telephone poles" (Dodwell, 1968, pp. 118-140), with matchsticks stuck in clay bases. The initial problem requires construction of the straight line on a rectangular table: first along the edge; secondly, across the center of the table; and finally, on a diagonal. The second problem requires the same three constructions, but utilizes a circular base (see Figure 2). At stage 1 (up to 4 years of age) the children were unable to form a straight line even when it ran parallel to the straight edge of the rectangular table. By stage 2 (approximately 4 to 7 years) the children were able to construct a

Insert Figure 2 about here

straight line when parallel to the edge of the table, but not on the diagonal or on the circular table. Stage 3 (beginning about 7 years) found the children able to build a straight line on either table no matter where it was to lie. To succeed, the child must be able to " . . . guide himself along referent axes which determine the creative position of individual elements in a space common to all of these elements (Larendeau & Pinard, 1970, p. 112). Spontaneously "aiming" or sighting along the line accomplishes this (Dodwell, 1968, pp. 118-140; Larendeau & Pinard, 1970; Piaget & Inhelder, 1965; Smock, 1976, pp. 31-73).

A second task used to study projective space was the projection of shadows. Several objects were mounted on rigid supports and then placed between a lamp and a white screen. The child was asked to draw the shape he expected the shadow to assume or to choose the shape from a set of sample drawings. For instance, a pencil was initially held vertically, then tilted toward the screen, and finally horizontally toward the screen so the resulting shadow was a small circle. At stage 1 the child had complete lack of understanding with regards to the projective shape of the shadow. During stage 2 there was some distinction among the projections, but it was at stage 3 that vertical and horizontal positions were clearly distinguished (Piaget & Inhelder, 1965).

A task which studied the development of projective space in terms of perspective used three miniature mountains (Dodwell, 1968, pp. 118-140; Piaget & Inhelder, 1965). A similar task used a house, tree, and tower to assess coordination of perspectives (Stephens, Miller, & McLaughlin, 1969; Stephens & Simpkins, 1974). Different reference points were placed on each mountain and the child was presented pictures representing each perspective. She/he was asked to choose the picture that best depicted how the mountains would appear from another position. For instance, if the child stood at A, which picture depicted the mountain scene from position C. Stage 1 children did not comprehend what the question requested. The stage 2 child did choose a picture, but was unable to distinguish between his own viewpoint and that of others depicted by alternative positions. Only at stage 3 could the child show progressive discrimination and coordination among the perspectives (Dodwell, 1968, pp. 118-140; Piaget & Inhelder, 1965; Smock, 1976, pp. 31-73).

Development of Euclidean space involved the concepts of parallel, angle, and proportion which provided the link between projective and Euclidean space. It differed from projective space in that the concepts of distance and measurement were introduced. Vertical and horizontal axes provided natural and simple frames of reference since they were available in the child's physical environment. To test the horizontality concept, the child was presented with two bottles containing a colored liquid, one with straight parallel sides, the other with rounded sides. The child was asked to predict by drawing the position of the liquid when the bottle was tilted (see Figure 3).

Insert Figure 3 about here

Verticality was tested by floating a cork with a pin in it in the water and asking the child to draw his/her prediction of the position of the "ship's mast" when the jar was tilted. An additional assessment of verticality required the child to plant posts "nice and straight" on a sand mountain (see Figure 4). In each task, stage 1 children exhibited an inability to distinguish surfaces or planes while stage 2 children presented intermediate responses such as drawing the water level parallel to the base of the jar or placing the posts perpendicular to the mountain. Only at stage 3 did the children resolve these difficulties and establish the concept of vertical and horizontal (Copeland, 1974, 1976; Dodwell, 1968, pp. 118-140; Piaget & Inhelder, 1965; Smock, 1976, pp. 31-73).

Insert Figure 4 about here

This cursory overview of the young child's development of the concept of space provides a framework from which we may begin examination of the blind child's development of space. To date the author has completed three investigations paralleling the work of Piaget and Inhelder (1965) and Larendeau and Pinard (1970) in an attempt to compare and define how the concept of space develops in young blind children. It is anticipated that this work may lead to a better understanding of the blind child's functioning and thus, influence the teaching of mobility and orientation skills, as well as the construction of maps, diagrams, models, etc., which involve spatial understanding.

Footnote

Dr. Simpkins was an educational research scientist at the American Printing House for the Blind when this study was conducted. Presently, she is assistant professor in educational psychology at Brigham Young University.

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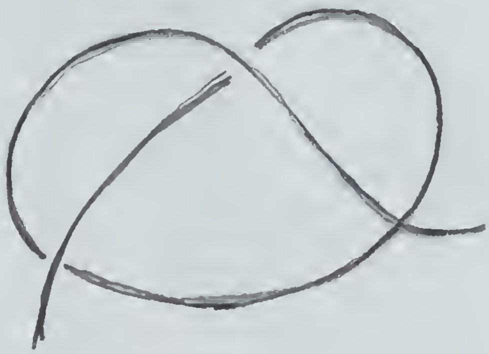
Figure Captions

Figure 1. Example of the enclosure relationships with knots.

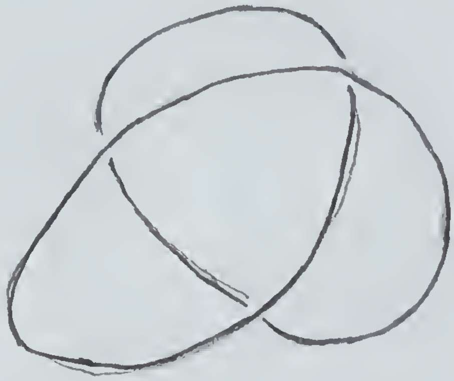
Figure 2. Examples of three developmental stages in constructing the projective straight line.

Figure 3. Examples of three developmental stages of the idea of verticality.

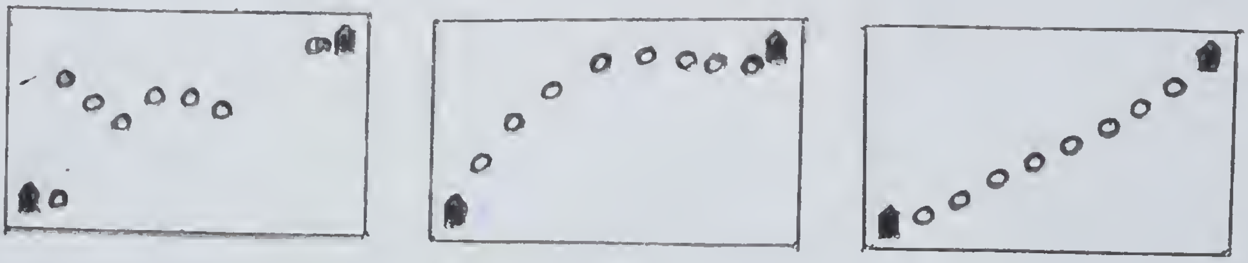
Figure 4. Examples of three developmental stages of the idea of verticality.



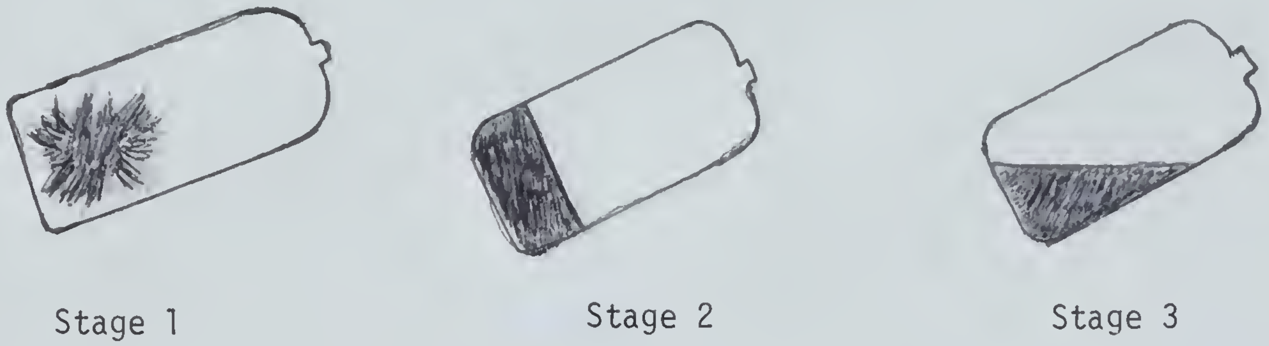
True Knot



Pseudo Knot



Stage 1 Stage 2 Stage 3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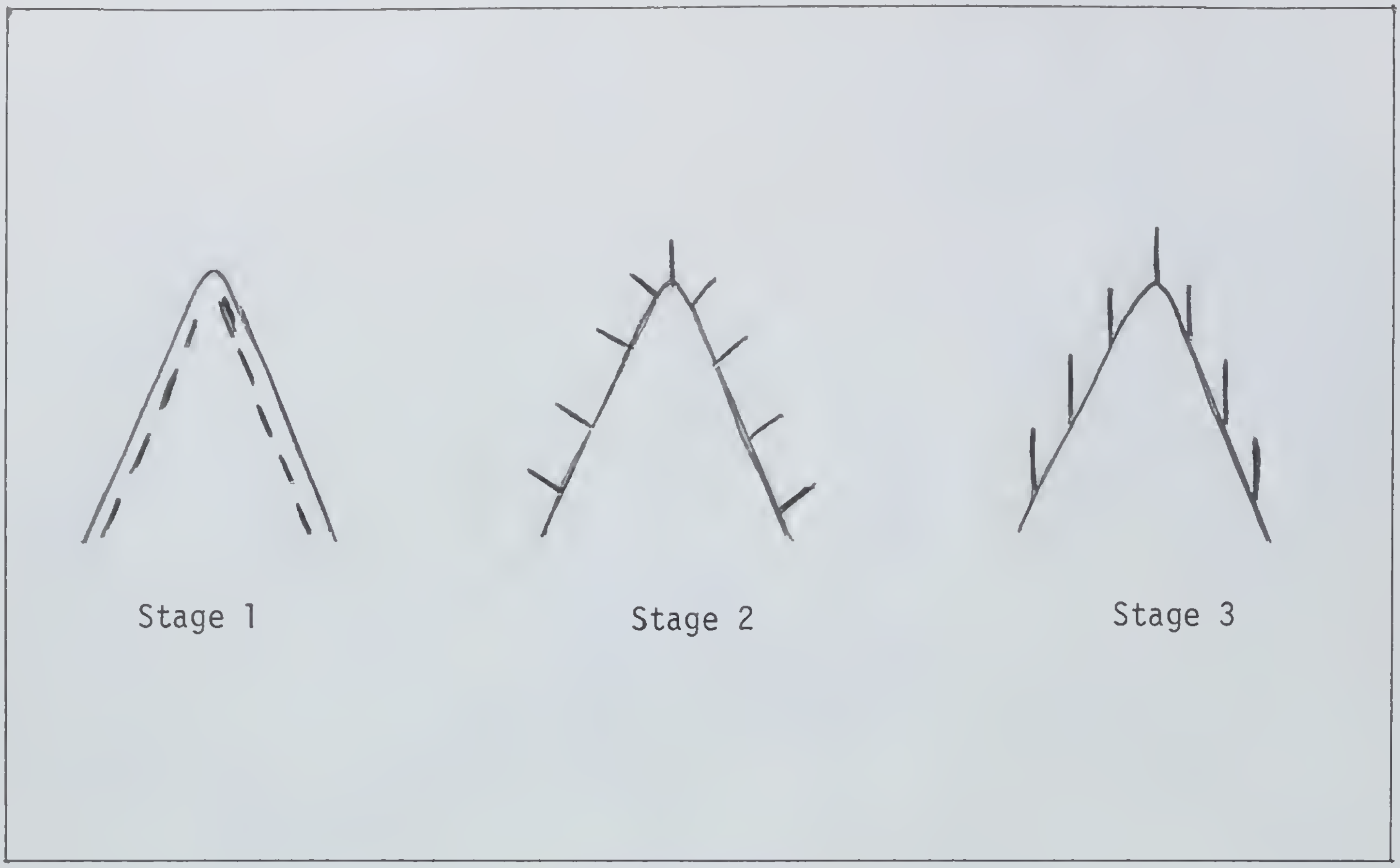
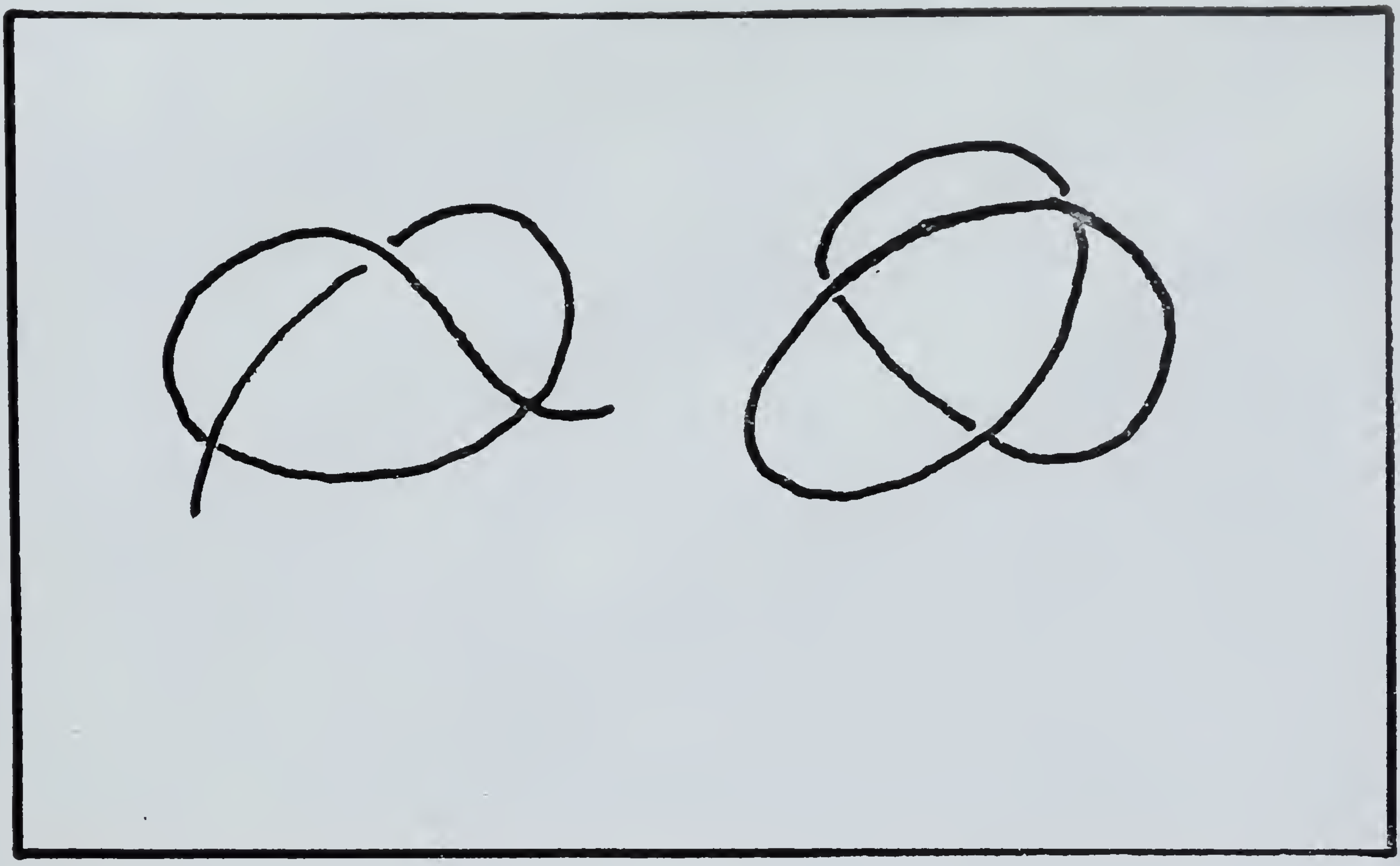
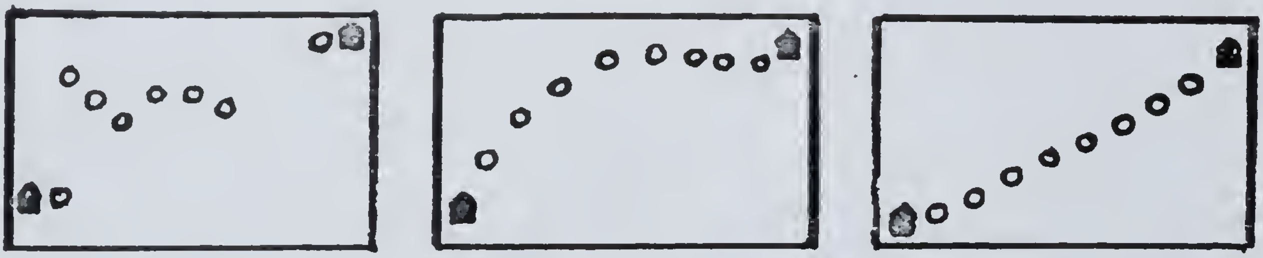


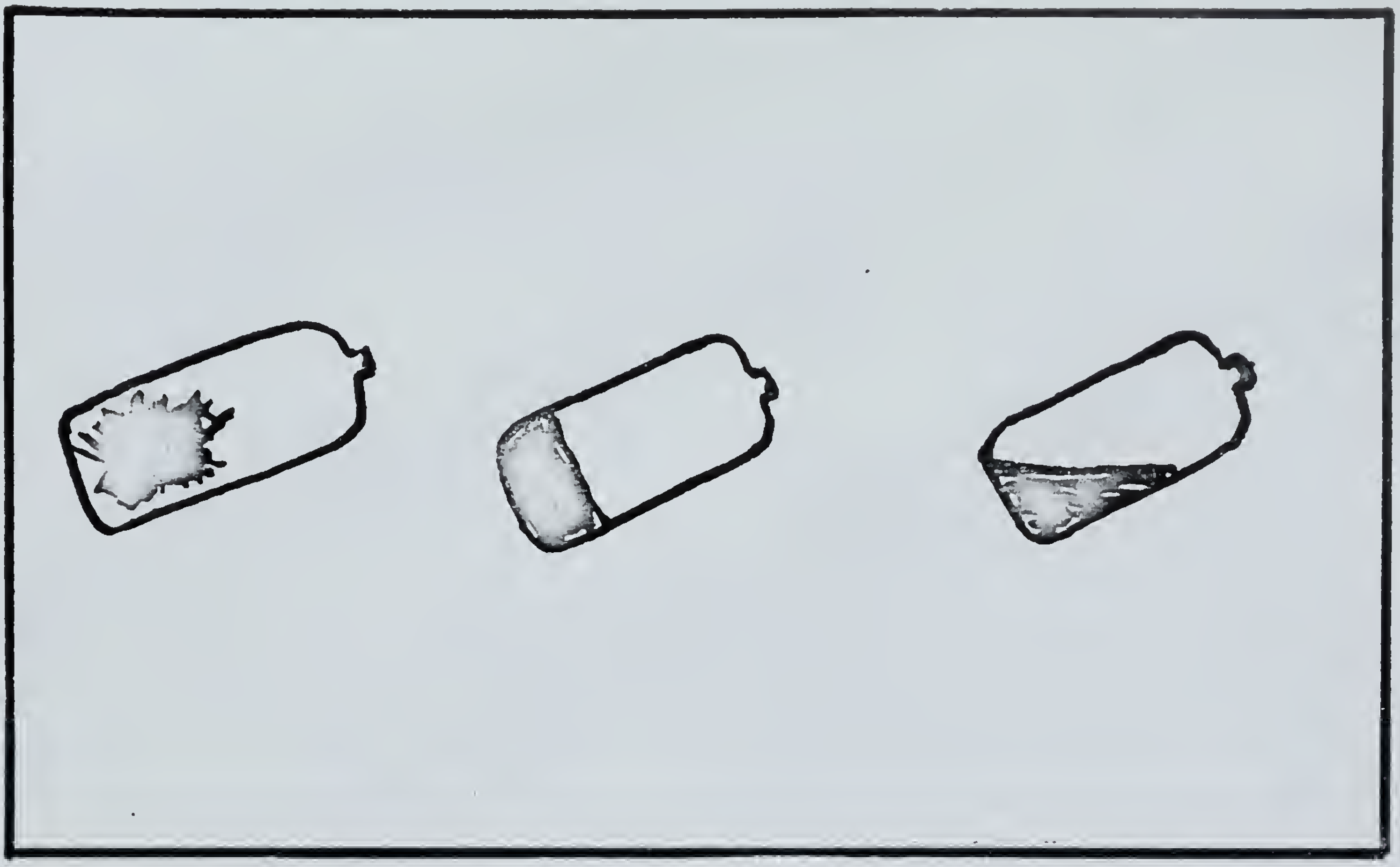
Stage 1

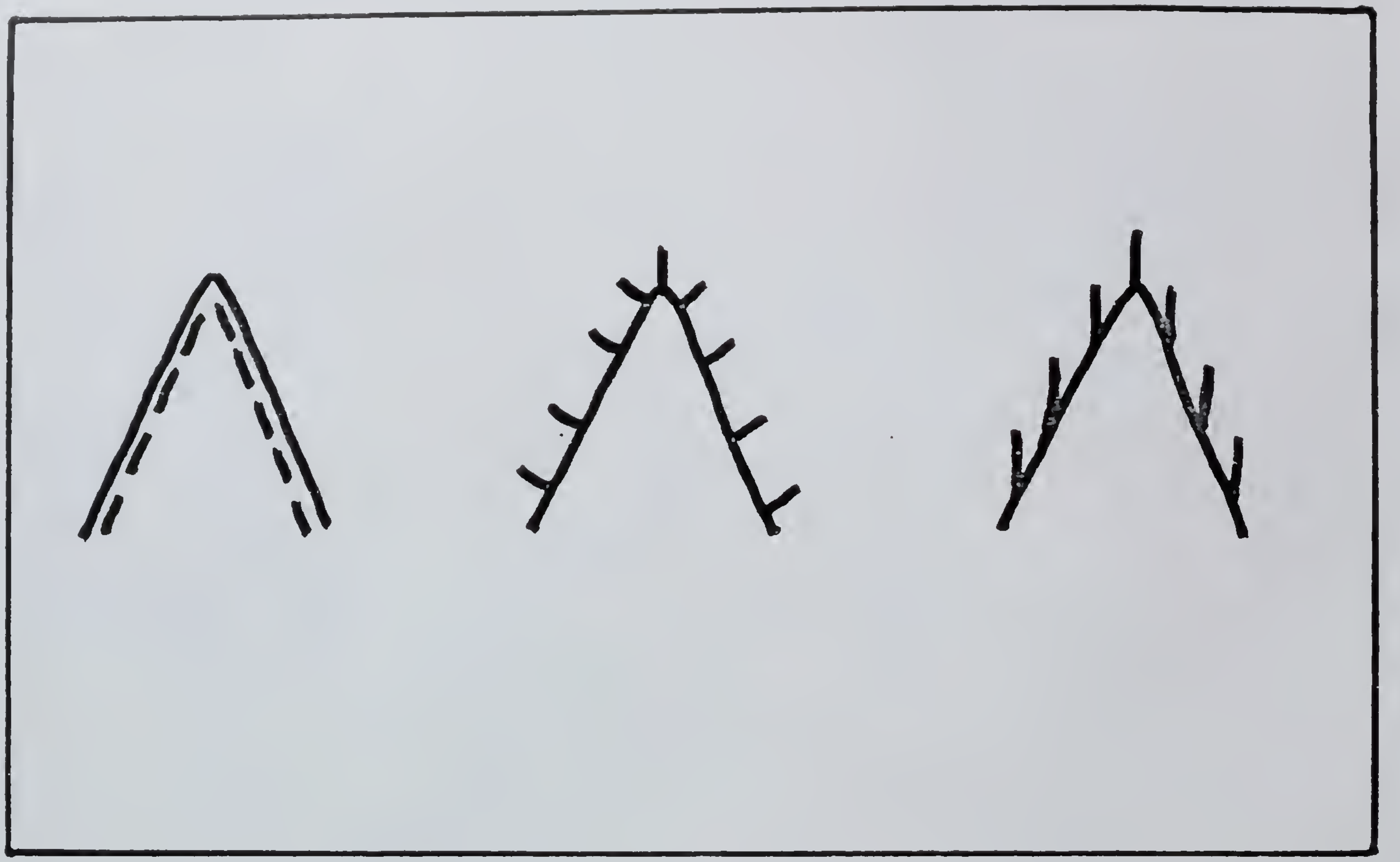
Stage 2

Stage 3









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